MR Image Segmentation Methods:A Survey

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Abstract - In today's modern medical image research, MR image segmentation is the most challenging task. The basis of MRI is the directional magnetic field, or *moment,* associated with charged particles in motion. These images are used to produce images of soft tissue of human body. It is used to analyze the human organs without the need for surgery. A large variety of algorithms for segmentation of MRI images had been developed, there is yet no universal algorithm for medical image segmentation. An algorithm's advantages and drawbacks often vary according to the problem under investigation. In this paper, we present a review of the methods used in brain MRI image segmentation. Current segmentation approaches are reviewed with an emphasis placed on revealing the advantages and disadvantages of these methods for medical imaging area.

Keywords- Bias field, Brain tumor, MR Image, Segmentation,

I. INTRODUCTION

The segmentation of brain tumor from magnetic resonance (MR) images is a vital process for treatment planning, monitoring of therapy, examining efficacy of radiation and drug treatments, and studying the differences of healthy subjects and subjects with tumor. The process of automatically extracting tumors from MR images is a challenging process [1] [4] [5]. This leads to many different approaches for automatic tumor segmentation. Medical image acquisition devices and protocols that have tremendously evolved over the last decades provide a vast amount of data out of which the information essential for diagnosis, therapy, planning and execution, and Monitoring. The outcomes of most medical imaging modalities are of gray scale intensities. Suppose a medical image I(x, y), where x($\in$[1, N_x]) and y($\in$[1, N_y]) are spatial indices, and the pixel i(x, y) quantifies the corresponding intensity. Image segmentation is to find a set of meaningful subclasses $\mathbf{S}_k$, where

$$\cup S_k = 1 \quad (1)$$

$$S_K \cap S_j = \Phi \quad (2)$$

The indices k and j lie in the interval [1, K] and K is the number of subclasses. Equation (1) claims that an image segmentation should be complete, while Equation (2) requires it to be non-overlapping. Methods for performing segmentations vary widely depending on the specific application, imaging modality, and other factors. For example, the segmentation of brain tissue has different requirements from the segmentation of the liver. We will see methods in context of detection of tumor from MR image of Brain.

Bias field [5] is low frequency smooth undesirable signal that corrupts MRI images, blurs it and reduces the high frequency contents of images and changes the intensity value of image pixel which degrades performance of image processing algorithms. A pre-processing step is needed to correct effect of bias field [7] [1] before performing image processing through segmentation and classification algorithms. It can be modeled as a multiplicative component of an image as shown:

$$I = bJ + n$$

where *I* is the observed image, *J* is the true image to be restored, *b* is an unknown bias field, and *n* is the additive zero-mean Gaussian noise [1].The given figure shows different classes like grey (tissues) matter, white matter ,tumor region and many other regions present in brain.

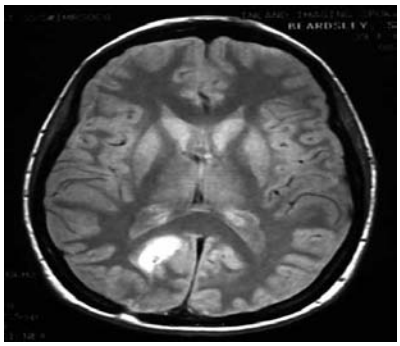

Figure 1. MR Brain image with Tumor

II. LITERATURE REVIEW

The main obstacles in segmentation are [1] [6] [5] [9]:

- Noise
- The bias field (the presence of smoothly varying intensities inside tissues)- MR images contain unwanted intensity variation due to inhomogeneity in the ``uniform'' magnetic field. The overall intensity variation, referred to as *RF inhomogeneity*,
- The partial volume effect – A voxel contributes in multiple tissue types

A . Bias Field Correction methods Review

Two main common methods have been applied to minimize the intensity inhomogeneity in MR images, including the prospective approach which based on phantoms, multicoils, and special sequences, and the retrospective approach as filtering, surface fitting, segmentation, and histogram based. The former one aims at calibration and improvement of the image acquisition process, and the latter relies exclusively on the information of the acquired image and some a priori knowledge [25]. Retrospective approaches are given below.

1] Filtering Methods

Filtering methods assume that intensity inhomogeneity is low-frequency artifact that can be separated from the high-frequency signal of the imaged anatomical structures by low-pass filtering[6],but sometimes this assumption is not valid because For most of the anatomical structures imaged by MR this assumption does not hold, which results in overlap of anatomy and inhomogeneity frequency spectra[6].

1] Surface Fitting Methods

These methods fit a parametric surface to a set of image features that contain information on intensity inhomogeneity. The resulting surface, which is usually polynomial or spline based, represents the multiplicative inhomogeneity field that is used to correct the input image[5][6]. A common practice for images that are unevenly illuminated is to divide the corrupted image by a background image represents an estimate of the variation in the illumination across the image. The same can be done for MRI images corrupted by bias field signal. The background image is normally estimated from the corrupted image by low pass filtering operation. Since it is very difficult to design an optimal low-pass filter that has sharp cut-off frequency and at the same time has no ripples in the pass-band and stop-band regions, the background image estimated this way has some noise introduced such as ripples in the image and ringing around the edges[5].To improve the quality of the background image, a two-dimensional surface equation is fitted to data points selected from the background image and then the fitted equation is used to generate the bias field signal. The bias field signal obtained this way is much smoother than the background image obtained using a low-pass filtering operation alone.

2] Segmentation Based Methods

In segmentation based intensity inhomogeneity correction methods these two procedures are merged so that they benefit from each other, simultaneously giving better segmentation and inhomogeneity correction [5] for example Finite mixture and more frequently Fuzzy C –mean[4] ,finite Gaussian mixture models [1] are used and modified to incorporate intensity inhomogeneity.

3] Histogram Based Methods

These methods operate directly on image intensity histograms and need little or no initialization and/or *a* priori knowledge on the intensity probability distribution of the imaged structures [6].This makes these methods fully automatic and highly general so that they can usually be applied to various images with or without pathology. Although a number of segmentation based methods also operate on image intensity histograms, the distinction between the segmentation based and histogram based methods is that the latter provide no segmentation results [6].

High-Frequency Maximization-A well-known intensity inhomogeneity correction method. The method [11] is fully automatic, requires no a priori knowledge and can be applied to almost any MR image. Interestingly, no improvements have been suggested for this highly popular and successful method.

Information Minimization-These methods are based on the assumption that intensity inhomogeneity corruption introduces additional information to the inhomogeneity-free image. Intensity inhomogeneity removal is, therefore, based on constrained minimization of image information, which is estimated by image entropy. Image entropy [12] [6] can be computed from the original intensity distributions or from the log-transformed distributions. numerical computation of entropy becomes far more difficult due to the nonlinear log-transformation of image intensities [6].

B. Image Segmentation Methods Review

There are two types Segmentation [8] -Soft Segmentation and Hard Segmentation. Segmentations that allow regions or classes to overlap are called soft segmentations. Soft segmentations are important in medical imaging because of partial volume effects, where multiple tissues contribute to a single pixel or voxel resulting in a blurring of intensity across boundaries [8] [4]. A hard segmentation forces a decision of whether a pixel is inside or outside the object or class. Soft segmentations based on membership functions can be easily converted to hard segmentations by assigning a pixel to its class with the highest membership value. Automated segmentation and delineation of detailed structures remains a difficult task in MRI segmentation [25]

Techniques such as Graph cut based ,Watershed, threshold ,The region growing , Clustering The active control model, A Markov random field models, Segmentation for brain with atlas approaches and Artificial neural networks (ANNs) will be discussed next briefly

1] Thresholding

Its presents an automatic image segmentation method using thresholding technique [3] [13]. This is based on the assumption that adjacent pixels whose value (grey level, color value, texture, etc) lies within a certain range belong to the same class and thus, good segmentation of images that include only two opposite components can be obtained.Threshold based image segmentation are Global Thresholding, Local Thresholding, and Adaptive Thresholding**.** The key parameter in image segmentation using thresholding technique is the choice of selecting threshold value T.

2] Watershed

Watershed is a gradient-based segmentation technique where different gradient values are considered as different heights. A hole is made in each local minimum and immersed in water, the water will rise until local maximums. When two body of water meet, a dam is built between them. The water rises gradually until all points in the map are immersed. The image gets segmented by the dams. The dams are called watersheds and the segmented regions are called catchments basins [23] [22] [9]. The watershed algorithm uses concepts from mathematical morphology [24] to partition images into homogeneous regions

3] The Region Growing

The region growing starts with a seed, which is selected in the centre region of interest. During the region growing phase, pixels in the neighbor of seed are added to region based on homogeneity criteria thereby resulting in a connected region [9].The methods are available for selection of seed or it can be done with prior knowledge.

4] Graph cut based

The problem of image segmentation is considered as a graph partitioning problem [14] [9] and global criterion that measures both total dissimilarity among the different groups and the total similarity inside then is used. An efficient method based on generalized Eigen value treatment is used to optimize the criterion to segment image [12].

5] Clustering

Clustering algorithms essentially perform the same function as classifier methods without the use of training data. Thus, they are termed *unsupervised* methods. Two commonly used clustering algorithms are the k -means [15], the fuzzy c-means algorithm. The K-means clustering algorithm clusters data by iteratively computing a mean intensity for each class and segmenting the image by classifying each pixel in the class with the closest mean and fuzzy c-mean [4][7]has membership function based on membership values it divides pixel into different classes .Its also iterative based method.

6] Active Contour Method

It is based on a curve, and used for delineating an object outline from a noisy image. The internal energy and is used to control the tension and rigidity of the deforming curve. The external energy is used to guide the deforming curve toward the target [16] used Gaussian Gradient Force to compute external force. Advantages of this method are insensitiveness to contour initialization, boundary concavities, saving computation time, and high accuracy [16] [9].

7] A Markov random field models

Markov random field (MRF) modeling itself is not a segmentation method but a statistical model which can be used within segmentation methods [8] MRFs model spatial interactions between neighboring or nearby pixels. These local correlations provide a mechanism for modeling a variety of image properties [17] [9]. In medical imaging, they are typically used to take into account the fact that most pixels belong to the same class as their neighboring pixels. In physical terms, this implies that any anatomical structure that consists of only one pixel has a very low probability of occurring under a MRF assumption. MRFs are often incorporated into clustering segmentation algorithms such as the Kmeans algorithm under a Bayesian prior model [17] [18] [19] [9].

8] Artificial neural networks (ANNs)

ANNs represent a paradigm for machine learning and can be used in a variety of ways for image segmentation. In medical imaging. It is used is as a classifier where the weights are determined using training data, and the ANN is then used to segment new data. It can also be used in an unsupervised fashion as a clustering method [20] [21].

9] Segmentation of MR image with Atlas-guided approaches

Atlas-guided [13] [9] approaches are an effective tool for medical image segmentation when a standard atlas or template is available. The atlas is generated by compiling information on the anatomy that requires segmenting. This atlas is then used as a reference frame for segmenting new images. It first finds a one-to-one transformation that maps a pre-segmented atlas image to the target image that requires segmenting. This process is often referred to as *atlas warping* [9].

III. CONCLUSION AND FUTURE WORK

This paper gives review of current methods used for MR image segmentation. Methods and Techniques that have appeared in the recent literature are briefly described. We refer only to the most commonly used Bias field correction and Segmentation methods. As we know ongoing research in biological world, increasing new knowledge about different disorders is rapidly coming up before us .Future research in the segmentation of medical images will need to take care towards improving the accuracy, precision, and computational speed of segmentation methods, as well as reducing the amount of manual interaction as Computerized segmentation methods have shown their utility in research application to improve of clinical studies.

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